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N93-21414

Trajectory Control Sensor Engineering Model Detailed Test Objective

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P-1

The concept employed in an existing Trajectory Control Sensor (TCS) breadboard is being developed into an engineering model to be considered for flight on the Shuttle as a Detailed Test Objective (DTO). The sensor design addresses the needs of Shuttle/SSF docking/berthing by providing relative range and range rate to 1500 meters as well as the perceived needs of AR&C by relative attitude measurement over the last 100 meters. Range measurement is determined using a four-tone ranging technique. The doppler shift on the highest frequency tone will be used to provide direct measurement of range rate. Bearing rate and attitude rates will be determined through back differencing of bearing and attitude, respectively. The target consists of an isosceles triangle configuration of three optical retroreflectors, roughly one meter and one-half meter in size. After target acquisition, the sensor continually updates the positions of the three retros at a rate of about one hertz. The engineering model is expected to weigh about 25 pounds, consume 25-30 watts, and have an envelope of about 1.25 cubic feet.

Concerns addressed during the presentation: Are there any concerns with differentiating attitude and bearing to get attitude and bearing rates? Since the docking scenario has low data bandwidth, back differencing is a sufficient approximation of a perfect differentiator for this application. Could range data be obtained if there were no retroreflectors on the target vehicle? Possibly, but only at close range. It would be dependent on target characteristics.

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N93-21415

Thruster Configurations for Maneuvering Heavy Payloads

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The Cargo Transfer Vehicle (CTV) will be required to perform six degree of freedom (6 DOF) maneuvers while carrying a wide range of payloads varying from 100,000 lbm to no payload. The current baseline design configuration for the CTV uses a forward propulsion module (FPM) mounted in front of the payload with the CTV behind the payload so that the center of gravity (CG) of the combined stack is centered between the thruster sets. This allows for efficient rotations and translations of heavy payloads in all directions; however, the FPM is a costly item, so it is desirable to find design solutions that do not require the FPM. This presentation provides an overview of the analysis of the FPM requirements for the CTV.

In this study, only the reaction control system (RCS) thruster configurations are considered for 6 DOF maneuvers of various CTV cargo configurations. An important output of this study are the viable alternative thruster configurations that eliminate the need for the FPM. Initial results were derived using analytical techniques and simulation analysis tools. Results from the preliminary analysis were validated using our 6 DOF simulation.

Using current baseline thruster locations on a main CTV without the FPM, operations are possible with 75 lbf thruster and 19% fuel efficiency (a 400 lbm fuel penalty) for lateral maneuvers of 100,000 lbm cargo within the final 1000 ft approach. The CTV without its cargo or strongback requires low torque (7.5 lbf thrust), but available 25 lbf thrusters yield 3.4 degrees per square second of rotation acceleration, which implies frequent and fuel-inefficient thruster activity and excessive angular acceleration. An alternative 36-thruster configuration with offset 25 lbf thrusters can achieve 24% efficiency and handle both fully loaded and core CTV operations.